Stop making sense!

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How many times have you been speaking at rounds or seminars when, after going through a complex argument about a convoluted process requiring some attentiveness, a listener answered you with what you know to be a fake look of understanding: 'Yes, it makes sense'? The correct response would have been, 'Wow! Who would have thought? It doesn't make sense at all!'

Making sense seems to me to be the most trivial attribute of any scientific or medical issue. What is the point of research? Surely it is not to find something that merely makes sense? To make sense of something, all one has to do is to rely on 'conventional wisdom,' which is simply the product of our accumulated knowledge. We acquire knowledge throughout our lives by experiencing the world, seeing how it looks, hearing how it sounds, and so on. Philosophers have always worried about the problem of intellection, that is, how we experience and know the world and ourselves in it. These ideas were formalized by Ibn Sina (known to the West as Avicenna), who stated that there are four types of internal thinking (the soul, in his terminology), two of which are relevant to this discussion: *common sense* and *imaginative thinking*. Common sense was seen to be the mechanism of generating an object of knowledge by fusing the information obtained from our senses. Imaginative thinking, on the other hand, combines a variety of images stored in our memory and fuses them to form a new image.

While common sense is useful for ordinary interaction among people, it is of little use in finding out new things. In scientific research, common sense often leads to trivial insights. This is due to at least two factors. The first is that our sensory input is severely limited. For example, we see or hear only a mere fraction of the wavelengths that are possible; hence our knowledge of the other types of radiant energy is beyond our experience. On the other hand, we do possess a reasonable sense of temperature and pressure, since these can be felt directly by our senses. We find it easier to understand the science of phenomena that are dominated by our sensory perception — the classical theory of color, elementary aspects of energy balance (that is, the relationships of temperature and pressure). It helps that many of these phenomena can be described in qualitative prose. Once one enters into a quantitative analysis, the glazed look becomes the natural response.

The second reason for our limited scientific intuition is that our experience of life is dominated by our size. We experience the world around us with a unique sense of what is large and small, a sense that is likely to be very different from that of flies or whales. Our experience, thus, is dominated by gravity, but we have no firsthand knowledge of surface tension, for instance; were we insects that lived on the surface of water, our notion of classical mechanics would be incredibly different. Hence one can easily assert that the evolution of humankind was dominated by our need for survival within these dimensions. Thus our brains (the product of this evolution) can only interpret the world within these limitations, limitations that are not conducive to coming up with general insights into the laws of nature, which require understanding of atoms and universes.

It is clear that humankind acquired knowledge by observation and cultural transmission and thus developed an intuition based on personal experience that allows us to make deductions from the observable facts that can be verified by our experience. These conclusions appear to be 'naturally' correct because they fit with our 'instinctive' understanding of science and problem solving. Ancient physicists eventually codified this knowledge, and this is probably part of why the Greeks, in particular Aristotle, are held in such high regard; their conclusions sound so 'natural' that they must be correct. We, of course, now know better; as always in science we have to guard against allowing beauty to substitute for truth.

Of course the reality of science is completely different and even counterintuitive. We have difficulty understanding the big and the small; the universe and subatomic particles. Even classical mechanics is not easy to grasp; how could Newton's Laws of Motion be intuitive when our experience with throwing a ball tells us that it falls to the ground? On the basis of our senses alone we cannot believe what

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solid-state physics tells us, that a hard rock is a crystal of atoms and that most of the volume in that rock is actually a void. Try telling that to the person who is hit by a stone. We cannot see that the universe is expanding. The list is interminable. One or two more examples will suffice. Is there any sense behind why proteins are made only of L-amino acids but carbohydrates are composed only of D-sugars? These stereoisomers are identical in any chemical function you can think of except that their use in biology is strictly determined by one or the other isomer. From our own field, we know that the congenital absence of one kidney is a common occurrence; how could this happen? We know that we have two identical kidneys and their development occurs simultaneously; unlike the heart and some other organs, the kidneys are bilaterally symmetrical.

Despite all of these problems we can learn to think about the invisible, the immaterial, and the counterintuitive. It is here that learning most resembles the *imaginative thinking* of Ibn Sina. We learn to develop new intuitions that are far from those obtained by common sense. We can easily learn about friction in the observable universe such that it becomes 'second nature' to us. Or we can learn to recognize the importance of surface tension during cooking. Each of us can learn to discuss transport of molecules across membranes, yet we actually have no perception of Brownian motion ourselves; we are just too heavy to 'feel' it. Some subjects remain almost impenetrable; the two pillars of modern science, quantum mechanics and statistical mechanics, rarely if ever become second nature to most people. This suggests that there is a hierarchy of difficulties that we must overcome before we can be comfortable in a statistical or quantum world. The closer a subject is to our perceptual abilities and to our scale, the easier it is, and the more quantitative the basis of the phenomenon, the more difficult it becomes.

This hierarchy is not difficult to discern; we notice it when we teach students. The function of the heart and the cardiovascular system is relatively easy to understand and teach. The action of the heart as a pump is readily quantifiable, but no equations are necessary to understand its most clinically significant functions. Compare that with the kidney, an organ whose study was, and is, dominated by transport physiology, a subfield actually of physical chemistry. When we get to modern biological science with its emphasis on molecules, pathways, and other things outside our immediate sensory understanding, our intuition gets completely befuddled. Hence, one can categorically state that new discoveries in this area will never be in the purview of common sense. A corollary is that if a conclusion makes sense, it is probably wrong; although you might think this is debatable, it is more often the case than not.

It is possible that this analysis is an idiosyncrasy of mine, but I think we all share it; I bring as evidence the letters that we all write in support of granting awards, prizes, and promotions of colleagues, in which we need to describe their work in a positive light. Those letters are always full of phrases of the form: 'she had this unexpected finding' or 'he made the surprising observation…' No one recommends somebody by saying that he or she discovered something that made sense; in other words, it could be predicted because it made sense. We end by agreeing with J.B.S. Haldane (*Possible Worlds and Other Papers*, Harper and Brothers, 1928, p286) that the universe is not only "queerer than we suppose; it is queerer than we *can* suppose."